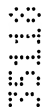


ABSTRACT

There is illustrated a method for manufacturing expanded polystyrene foam. Expanded polystyrene foam is placed in a microwave-oven safe mould and microwaved for a period of 7 minutes. Water is next added to the polystyrene, and the mixture microwaved another 7 minutes. A further period of microwaving of 1-5 minutes is required to yield a dried foam material.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for manufacturing or recycling expanded polystyrene foam materials from expanded polystyrene foam using microwave technology.
2. The method of claim 1 wherein said foam is microwave heated and moulded within a microwave-safe plastic mould.
3. The method of claim 2 wherein said microwave-safe plastic mould is constructed with holes or vents to allow release of gas or steam generated during heating of said expanded polystyrene foam material.
4. The method according to claim 1 wherein said new expanded foam materials are produced from virgin expanded foam.
5. The method according to claim 1 wherein said new expanded foam materials are produced from a combination of virgin and waste (used) expanded polystyrene foam, such that, subsequent to microwaving, combined materials are fused together to form a new unit of expanded foam material.
6. A new or recycled expanded polystyrene foam article manufactured by or comprising materials manufactured according to the method of claim 1.
7. The method according to claim 1 comprising the steps of:-
  - (i) providing a microwave safe mould including vents;
  - (ii) preheating unexpanded foam in the presence of a foaming agent the mould for a predetermined time;
  - (iii) subsequently adding water to the mould;
  - (iv) heating the unexpanded foam in the presence of the water to cause foaming to fill the mould; and
  - (v) continue heating to expel excess water but not to an extent that the expanded foam is degraded.
8. The method according to claim 1 comprising the steps of:-
  - (i) finely dividing foamed polystyrene acquired for grinding;
  - (ii) storing the finely divided foam in the presence of a foaming agent to impregnate the foam with sufficient foam agent for further expansion;
  - (iii) providing a microwave safe mould including vents;

AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION FOR A STANDARD PATENT

Name of Applicant: ROGER GREGORY ELLWOOD

Actual Inventor(s): Roger Gregory Ellwood

Address for Service: INTELLPRO  
Patent & Trade Mark Attorneys  
Level 7, Reserve Bank Building  
102 Adelaide Street  
BRISBANE, QLD, 4000  
(GPO Box 1339, BRISBANE, 4001)

Invention Title: METHOD FOR MANUFACTURING, RECYCLING  
AND CURING POLYSTYRENE FOAM USING  
MICROWAVE TECHNOLOGY

Details of Associated  
Provisional Application(s) No(s): Australian Patent Application No. PP2375  
filed 17 March 1998.

The following statement is a full description of this invention, including the best method of performing it known to me:

METHOD FOR MANUFACTURING, RECYCLING AND CURING  
POLYSTYRENE FOAM USING MICROWAVE TECHNOLOGY.

**BACKGROUND OF THE INVENTION**

This invention relates to the manufacture, recycling and curing of  
5 polystyrene foam using microwave technology, and more particularly to the use  
of waste (used) and/or virgin expanded polystyrene foam materials in the  
production of new expanded polystyrene foam articles.

Polystyrene is a very versatile plastic that can be rigid or foamed; foam  
being a lightweight cellular material resulting from the introduction of gas  
10 bubbles into the reacting polymer. Expanded polystyrene (EPS) foam provides  
exceptional insulation and protecting properties, and is commonly used for  
residential, commercial and industrial applications including insulation, building  
materials, protective packaging, containers, lids, bottles, trays, tumblers, egg  
cartons and cups.

The production of expanded polystyrene foam conventionally begins with  
styrene monomer materials which are derived from crude oil. Various references  
disclosing more recent methods of production of polystyrene foam include U.S.  
Patent Numbers 4,048,208; 4,083,665; 5,217,660; 5,290,819 and 5,908,872,  
which are incorporated herein by reference.

According to the forementioned references, present conventional methods  
of manufacturing styrene require the production of steam to facilitate styrene  
expansion. Such methods are time-consuming, laborious and expensive, due to  
the large gas or fuel oil fired boilers employed for steam generation, and the  
multiplicity of chemicals and steps required. These inadequacies are further  
25 outlined.

Conventional methods of expanded polystyrene foam production require  
the use of many chemicals, added to facilitate or optimise the process. Such  
chemicals which include for example surfactants, suspension stabilisers, and  
antioxidants, are expensive, and further complicate the process.

30 An essential step in any of the above methods of polystyrene production,  
is the contact of the polystyrene foam pieces, prior to heating and expansion, with

a blowing agent, commonly pentane gas. This necessarily adds expense, time and further complication to the process, whilst increasing gas emission.

Foam fabrication by conventional methods requires the application of considerable heat and pressure to the said expanded polystyrene foam. Therefore  
5 moulds used in this fabrication process are made from stainless steel or other metal alloys, which further increases costs.

Typically, the conventional processes are inefficient, expansion taking hours, and evaporation of excess water days because steam is unable to penetrate well, the sealed styrene foam.

10 As a consequence of environmental concern, the production and use of expanded polystyrene foam articles has been questioned. Expanded polystyrene is undesirable because it is essentially non-biodegradable, thereby contributing to the ever-increasing waste-disposal problem. Few of the forementioned methods incorporate the use of waste (used) polystyrene for recycling. U.S. Patent No.  
15 5,217,660 describes a method for recycling expanded polystyrene foam materials, however, does not offer the advantages associated with microwave technology, and additionally, requires that prior to use, the foam be ground into small portions.

Heretofore, no method has been described wherein expanded polystyrene  
20 foam materials may be recycled in a simple, effective, cost-efficient and environmentally sound manner. Accordingly, such is the general object of the present invention, described in the following, it is also being noted that the present invention can also be applied to virgin foam materials.

#### OUTLINE OF THE INVENTION

25 It is an object of the present invention to provide a method for producing expanded polystyrene foam materials from expanded polystyrene foam using microwave technology.

It is another object of the present invention to provide a method for recycling expanded polystyrene foam which enables such materials to be re-used  
30 in the production of new expanded polystyrene foam articles.

It is a further object of the present invention to provide a method for producing new expanded polystyrene foam materials wherein said materials are

produced from either virgin expanded polystyrene foam, or waste (used) expanded polystyrene foam or a combination thereof, wherein the combined materials are fused together to produce a strong and durable product.

5 It is a still further object of the present invention to provide a method for producing expanded polystyrene foam materials from expanded polystyrene foam using microwave technology, wherein said foam is microwave heated and moulded within a microwave-safe plastic mould.

10 It is a still further object of the present invention to provide a method, in fulfilment of the above, which is highly effective, cost-efficient, environmentally sound, and readily implemented for recycling and small moulding applications.

15 In accordance with the foregoing objectives, a unique method for producing and recycling expanded polystyrene foam materials is described herein. Specifically, the invention employs microwave technology, as opposed to using steam as per conventional technology, to facilitate foam expansion and moulding.

20 According to the invention, polystyrene and water are combined in a plastic mould and microwaved, causing expansion of said expanded polystyrene foam pieces, with concomitant evaporation of moisture or water held within foam cells, such that said pieces are fused into a unit expanded polystyrene foam block.

25 Preferably the polystyrene in bead form is preheated before introduction of sufficient water for steam production and foaming of the bead under microwave heating.

30 Preferably heating is continued after full expansion to expel excess water but not so much as to degrade the final product. This can be done for a number of hours on one oven heat setting. In the case of used foam being recycled, a foaming agent such as pentane is introduced into the foam after the foam has been finely divided and then the finely divided foam is subjected to the same treatment as if it were virgin foam.

The microwave-safe plastic mould, is constructed with holes or vents to allow release of steam generated during heating and expansion of the polystyrene.

35 The structure and configuration of the said moulding unit may be varied. The parameters including the shape, size, and material of manufacture of the mould, the vent or pore sizes, shapes, number and distribution on the mould, can

be modified by those skilled in the art according to the type of microwave oven involved, the structural features of the final product, and other extrinsic factors.

Following microwaving, the newly-formed expanded polystyrene foam block can be further treated with various agents for example flame-proofing or anti-static agents, lubricants or dyes, conferring additional properties, or otherwise simply processed into sheets, blocks or other foam articles.

Where waste (used) expanded polystyrene foam is used, the process may be slightly modified. For example, polystyrene boxes can be recycled by part filling said box with virgin expanded polystyrene foam and water. The mixture is then microwaved such that the combined materials are fused together to produce a new foam block.

Alternatively, used expanded polystyrene foam in the form of pieces or reground bead can be mixed with virgin expanded polystyrene foam and water, for microwave, to produce new-formed expanded polystyrene foam.

Where reference is made specifically to polystyrene, it would be understood to those skilled in the art, that the process could equally apply to other plastics specifically vinyl aromatic monomers. Vinyl aromatic monomers which may be suitable for use in this invention include styrene, alpha-methylstyrene, vinyltoluene, isopropylstyrene, nuclear dimethylstyrenes, chlorostyrene, vinylnaphthalene, divinylbenzene, etc.

In regards to the above, used polystyrene foam may be obtained from a variety of sources, including but not limited to used insulation, protective packaging, building material, containers, lids, bottles, trays, tumblers, egg cartons and cups, and other comparable expanded polystyrene foam articles.

In respect of microwaving, it would be understood that particular parameters may be varied. In relation to microwaving time, this would be dependent on the wattage of the microwave, size of the mould and moulding materials, and desired properties of the expanded polystyrene foam article. However, caution should be taken to prevent overheating. Fitting the microwave with a variable magnatron will prevent such burning or overheating of the cured foam.

Preferably, prior to heating, waste (used) foam is ground back into foam bead and then stored in contact with pentane gas or some other foaming agent. Preferably, foam is stored within plastic bags or sealed styrene silo, and the pentane gas pumped into the silo or bag which are then left for approximately 14  
5 days or longer, depending on the volume of bead being stored. This allows time for the pentane gas to ingress the ground bead.

#### PREFERRED EMBODIMENTS

In order that the present invention may be more readily understood and be put into practical effect, reference will now be made to the accompanying  
10 examples which illustrate preferred embodiments of the invention.

##### Example 1

###### Materials:

1. Microwave safe container (500mls)
2. 10mls polystyrene
- 15 3. 75mls water

###### Method:

1. Styrene bead is microwaved for 7 minutes (time based on 800 watt microwave).
2. 75mls of water is added, the mixture microwaved a further 7 minutes.  
20 Full expansion is achieved at this time.
3. Further heating for 1-5 minutes yields a dried foam.

###### Observation:

The method yielded a high quality mould polystyrene block

##### Example 2

###### Materials:

- 25 1. Microwave safe container (500mls)
2. 10mls of finely divided used polystyrene foam reimpregnated with pentane
3. 75mls water

###### Method:

- 30 1. Styrene bead is microwaved for 7 minutes (time based on 800 watt microwave).



2. 75mls of water is added, the mixture microwaved a further 7 minutes.  
Full expansion is achieved at this time.

3. Further heating for 1-5 minutes yields a dried foam.

Observation:

5 The method yielded a recycled polystyrene block of acceptable quality.

**Example 3**

Materials:

- 10 1. Microwave safe container (500mls)  
2. 10mls polystyrene  
3. 75mls water

Method:

1. Styrene bead is microwaved for 7 minutes (time based on 800 watt microwave).  
15 2. 75mls of water is added, the mixture microwaved a further 7 minutes.  
Full expansion is achieved at this time.  
3. Further heating for approximately 20 minutes.

Observation:

20 The block showed sign of bead failure and shrinkage compared to the block of example 1.

**Example 4**

Materials:

- 25 1. Microwave safe container (500mls)  
2. 10mls polystyrene  
3. 75mls water

Method:

1. Styrene bead is microwaved for 7 minutes (time based on 800 watt microwave).  
30 2. 75mls of water is added, the mixture microwaved a further 7 minutes.  
Full expansion is achieved at this time.  
3. The foam is microwaved under lower heat for a predetermined number of hours to drive off remaining excess water.

Observation:

The method yielded a high quality mould polystyrene block

It should be understood that the just described embodiment merely illustrates principles of the invention in a preferred form. Many modifications  
5 may, of course, be made thereto by individuals skilled in the art without departure of the spirit and scope of the invention as set forth in the appended claims.

00  
01  
02  
03  
04  
05  
06  
07  
08  
09  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for manufacturing or recycling expanded polystyrene foam materials from expanded polystyrene foam using microwave technology.
2. The method of claim 1 wherein said foam is microwave heated and moulded within a microwave-safe plastic mould.
3. The method of claim 2 wherein said microwave-safe plastic mould is constructed with holes or vents to allow release of gas or steam generated during heating of said expanded polystyrene foam material.
4. The method according to claim 1 wherein said new expanded foam materials are produced from virgin expanded foam.
5. The method according to claim 1 wherein said new expanded foam materials are produced from a combination of virgin and waste (used) expanded polystyrene foam, such that, subsequent to microwaving, combined materials are fused together to form a new unit of expanded foam material.
6. A new or recycled expanded polystyrene foam article manufactured by or comprising materials manufactured according to the method of claim 1.
7. The method according to claim 1 comprising the steps of:-
  - (i) providing a microwave safe mould including vents;
  - (ii) preheating unexpanded foam in the presence of a foaming agent the mould for a predetermined time;
  - (iii) subsequently adding water to the mould;
  - (iv) heating the unexpanded foam in the presence of the water to cause foaming to fill the mould; and
  - (v) continue heating to expel excess water but not to an extent that the expanded foam is degraded.
8. The method according to claim 1 comprising the steps of:-
  - (i) finely dividing foamed polystyrene acquired for grinding;
  - (ii) storing the finely divided foam in the presence of a foaming agent to impregnate the foam with sufficient foam agent for further expansion;
  - (iii) providing a microwave safe mould including vents;

- (iv) preheating unexpanded foam in the presence of a foaming agent the mould for a predetermined time;
  - (v) subsequently adding water to the mould;
  - (vi) heating the unexpanded foam in the presence of the water to cause foaming to fill the mould; and
  - (vii) continue heating to expel excess water but not to an extent that the expanded foam is degraded.
9. The method according to any one of claims 2 or 7 or 8 wherein the mould is vented through vents so dimensioned and arranged that during expansion of the foam the mould is pressurised.

DATED this 17th day of June 1999

ROGER GREGORY ELLWOOD  
By his Patent Attorneys  
INTELLPRO